OLD RIVER PROJECT
ROCK-FILL INITIAL CLOSURE DAM

Hydraulic Model Investigation

TECHNICAL REPORT NO. 2-496

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PREFACE

This report is the sixth report on model studies made in connection with the design of the Old River control structures. A list of the earlier reports is printed on the inside of the front cover of this report.

The tests reported herein were authorized in a letter from the President, Mississippi River Commission, to the Director, U. S. Army Engineer Waterways Experiment Station, dated 11 July 1957, subject, "Model Study of Initial Old River Closure Dam," and were accomplished during the period July 1957 to May 1958.

The tests were conducted in the Hydraulics Division, Waterways Experiment Station, by Messrs. C. W. Brasfeild, B. E. Boggan, and A. D. Rooke, Jr., under the direct supervision of Mr. C. J. Powell and the general supervision of Messrs. F. R. Brown and T. E. Murphy.

Mr. F. B. Toffaleti of the Mississippi River Commission maintained close liaison with the Waterways Experiment Station during the course of the study and other interested engineers of the Mississippi River Commission made several observations of the model operation. Col. A. P. Rollins, Jr., CE, was Director of the Waterways Experiment Station during the period of the study, Mr. J. B. Tiffany was Technical Director, and Mr. E. P. Fortson, Jr., was Chief of the Hydraulics Division. Present Director of the Waterways Experiment Station is Col. Edmund H. Lang, CE.

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SUMMARY

One element in the plan to control flow from the Mississippi River into the Atchafalaya through Old River is a sand closure dam in Old River. Since high velocities would make it difficult to effect a closure by sand alone, a rock-fill dam is proposed for the initial blockage of flow through Old River. A 1:10-scale model of a 100-ft-wide section of the dam was constructed, both in the dry and during flow, and tested to determine the stability, amounts of seepage through the dam (which would affect velocities at the upstream site of the sand dam), and the effect on seepage of seal blankets on the upstream face.

Tests indicated that the proposed cross section for the rock-fill dam would be stable under all conceivable flow conditions regardless of whether the fill had been constructed in the dry or in flowing water. The seepage rate was somewhat greater when the closure dam was constructed in flowing water. In either case, an effective means of reducing seepage flow was the placement on the upstream face of a 4-ft-thick riprap blanket covered with finer material. Use of this seepage-reduction measure resulted in negligible velocities upstream in the vicinity of the sand-fill dam.

Tests also indicated the feasibility of using steeper slopes on the upstream and downstream faces of the rock-fill dam. Stability conditions appeared satisfactory with a 1-on-1 upstream slope and a 1-on-2 and 1-on-1 composite downstream slope, which would permit a reduction of about 40 per cent in the volume of rock required.

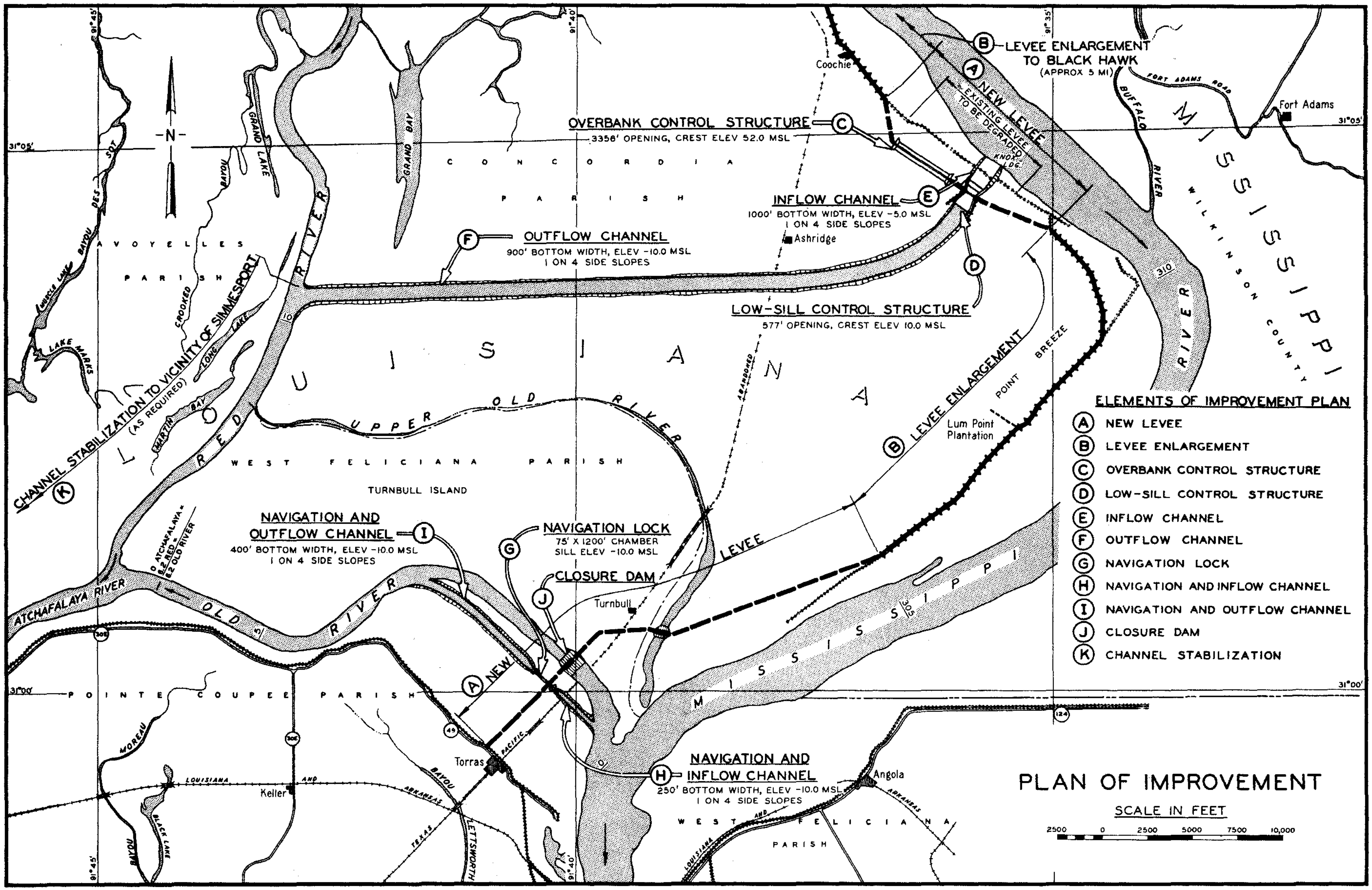

Fig. 1. Plan of improvement

OLD RIVER PROJECT
ROCK-FILL INITIAL CLOSURE DAM

Hydraulic Model Investigation

PART I: INTRODUCTION

1. The Atchafalaya River, a distributary of the Mississippi through the short connecting channel of Old River, has been increasing in capacity to such an extent as to threaten to divert the Mississippi River through its much shorter, and therefore steeper, route to the Gulf of Mexico. The following measures are proposed to control flow from the Mississippi and to prevent its capture by the Atchafalaya River: closing off the existing Old River channel with a dam and navigation lock; connecting the existing Mississippi River levees above and below Old River; and constructing control structures in the existing Mississippi River levee at a point about 10 miles above the mouth of Old River to regulate flow through a diversion channel into the Atchafalaya River. The elements of the control plan are shown in fig. 1. The tests reported herein were concerned with the rock fill that will be used for initial closure of the present Old River channel at the point marked "J" in fig. 1.

Description of Prototype

2. After completion of construction of the control structures the present Old River channel will be closed permanently with a sand-fill dam tying in with the main-line levee system. However, since velocities in Old River can become quite high, depending upon the amount of tributary flow from the Red-Ouachita backwater area, it is considered impracticable to effect a closure with sand alone. Therefore, it is proposed to make the initial closure of Old River by construction of a low-elevation rock-fill dam downstream from the site of the main dam. The rock-fill dam will be constructed during the high-water period of the year in which the closure is to be made so that the initial closure will be effected after the river begins to fall, as the stage of the falling river drops below

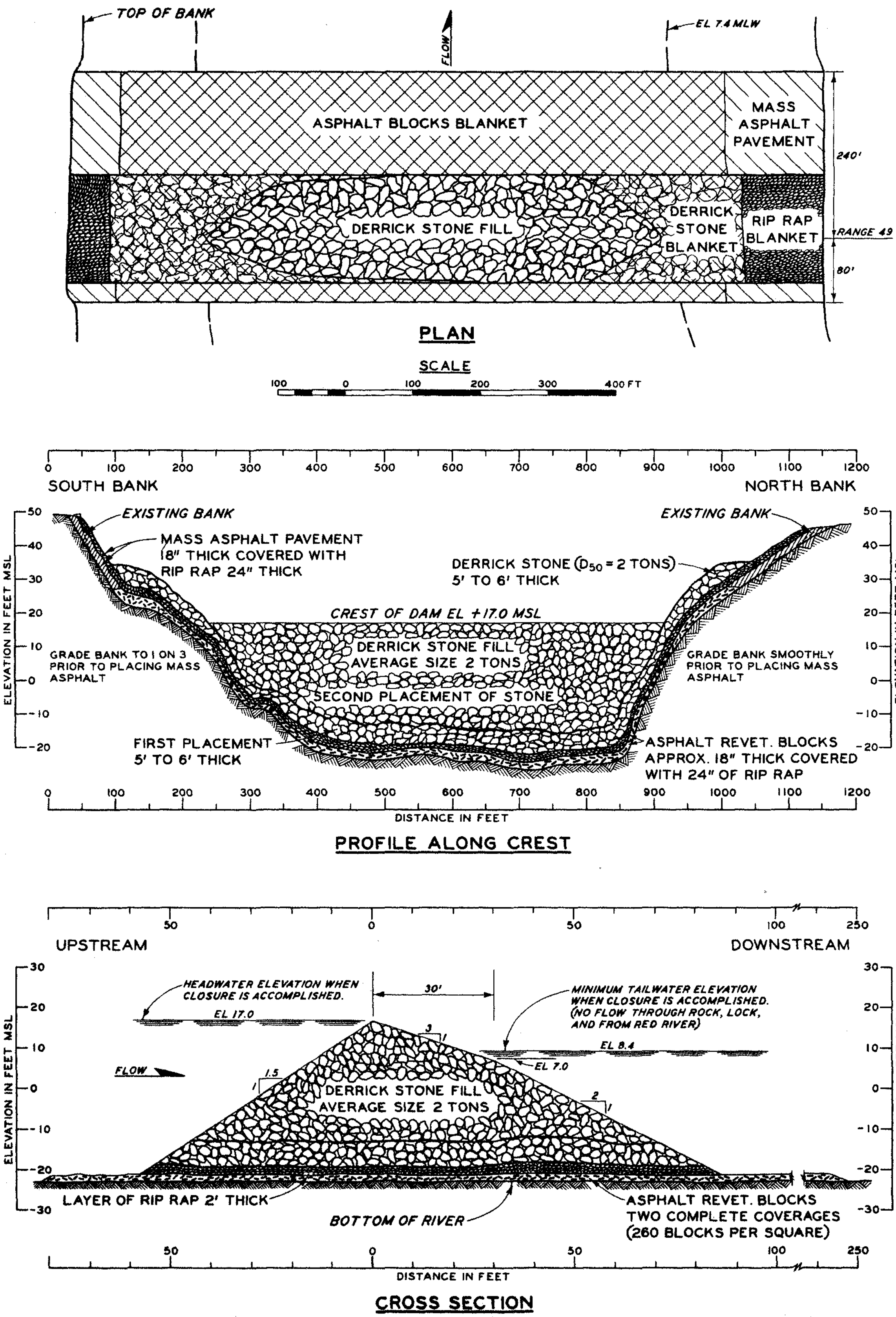

Fig. 2. Proposed design for the rock fill

the elevation of the top of the rock fill. Construction of the sand fill will be begun as soon as possible thereafter, and will be completed prior to the next high-water season.

3. The proposed design for the rock fill is shown in fig. 2. It is to be constructed of stones having a specific weight of about 160 lb per cu ft, with 65 per cent of the stones weighing at least 2 tons each. The maximum stone size will be about 4 tons and stones weighing less than 2 tons will be evenly graded to a minimum size of about 50 lb. Present plans call for the crown layer to consist only of stones weighing 2 tons or more. No such fill material is available in the locality of the structure, so the stones will have to be transported by river barge at considerable expense. The individual stones will be dumped into the flowing water, either from a cableway installed over the channel or from a derrick on a barge. If an unexpected flood should occur during the low-water season, flow over the crest of the completed rock fill would assume the general characteristics of one of the two profiles shown in fig. 3. It is anticipated that flows for headwater stages below elevation 30* would be the most critical for stability of the fill since a high-velocity nappe and a hydraulic jump would occur on the downstream 1-on-3 slope. The term stability, as used in this report, refers only to the stability of individual stones on the slopes of the fill and not to over-all structural stability.

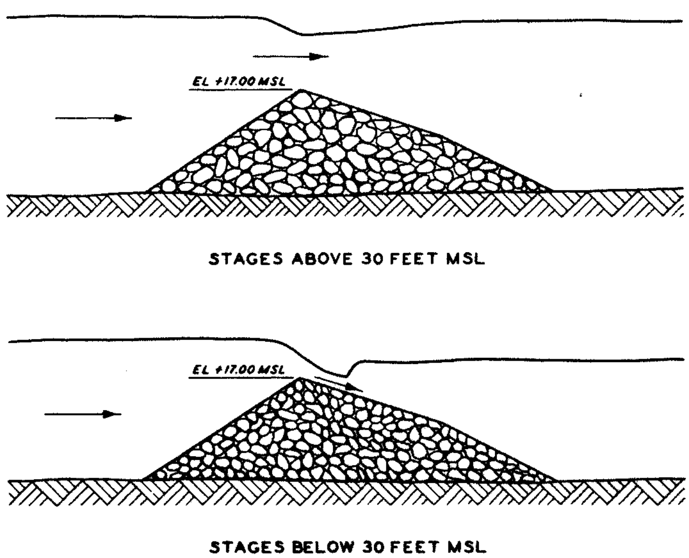

Fig. 3. Water-surface profiles over the rock fill for the Mississippi River stages indicated

Purpose of the Study

4. Hydraulic model studies of the proposed rock-fill closure dam were considered necessary for the following reasons:

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* All elevations are in prototype feet referred to mean sea level datum.

a. Design criteria for a closure structure of this type are meager. Since it is imperative that the closure dam remain in place even in the event of severe overtopping, it was considered desirable to investigate the stability of the structure thoroughly, particularly since the high cost of the fill material precluded overdesign of the section.

b. Determination of the rate of seepage through the fill was desired in order to get an indication of the velocities that will occur at the site of the main sand fill upstream during various stages of construction. Whether or not a seal blanket is needed on the upstream slope of the rock fill to prevent seepage and thus keep these velocities within a tolerable limit also was to be determined.

PART II: THE MODEL

5. The work of Isbash* and others indicates that hydraulic models, geometrically similar to the prototype and operated in accordance with Froude's law, can be used to predict the stability of riprap subjected to the action of flowing water. Froude's law is based upon the premise that gravity is the dominant flow factor for the structure or facility under consideration. In the Old River closure model study, geometric similitude was obtained by selection of a 1:10 undistorted scale; the requirements of dynamic similitude were satisfied by operation of the model in accordance with the Froudian relations. Scale relations, model to prototype, were:

Dimension	General	Numerical
Length	L_r	1:10
Area	$A_r = L_r^2$	1:100
Velocity	$V_r = L_r^{1/2}$	1:3.16
Time	$T_r = L_r^{1/2}$	1:3.16
Pressure	$P_r = L_r$	1:10
Discharge	$Q_r = L_r^{5/2}$	1:316

6. The model was constructed in the headbay area of an existing flume where an ample water supply was available. The width of the test facility was 10 ft and the depth was about 5.5 ft, thereby permitting construction of a 100-ft-wide (prototype) section of the rock fill. The floor of the flume was set at el -20, which limited the maximum Mississippi River stage to about el 30. The rock fill was constructed to el 17 of graded material (fig. 2). No attempt was made to reproduce the thin layers of riprap and asphalt revetment material forming the base of the closure dam.

7. Specifications for the model rock-fill material were: (a) specific weight, 160 lb/cu ft, and (b) gradation as shown in the following tabulation:

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* S. Isbash, Construction of Dams by Dumping Stones into Flowing Water (Leningrad, 1932). Translated by A. Dovjikov, War Department, United States Engineer Office, Engineering Division, Eastport, Maine, September 1935.

Particle Size, in.	% of Total Weight
4-1/2 to 3-1/2	65
3-1/2 to 2	18
2 to 3/4	17

These sizes were established by assuming the prototype stones to be cube-shaped and reducing the side of the prototype stone by a factor of 10. The stone used in the model met the above-listed specifications except for specific weight, the model stones weighing 168.2 to 169 lb per cu ft. However, the model stones were shipped from the area in Tennessee where the prototype stone is to be procured. Therefore, the heavier specific weight was considered representative of the stone that will actually be used in the rock fill.

8. Discharges were measured by means of a pitometer mounted in a 36-in. supply pipe and a 12- by 6-in. venturi meter; tailwater elevations were adjusted by raising or lowering a hinged tailgate at the end of the model; and water-surface elevations were read on staff gages mounted on the walls of the flume. Stability of the slopes of the rock closure section was determined visually. The amount of seepage flow was determined by the establishment of head-discharge relations with and without a seal blanket on the upstream face of the closure section.

PART III: TESTS AND RESULTS

9. For all tests, pool and tailwater elevations for various discharges were set in accordance with stage-discharge data (table 1) furnished by the Mississippi River Commission. Pool elevations are dependent on the stage of the Mississippi River, whereas tailwater elevations are determined by the stage of the Red-Atchafalaya River and flow past the closure dam. The stages of both rivers will be influenced to some degree by the amount of flow diversion through the proposed Old River control structures.

Rock Fill Constructed in Dry

Construction of closure section

10. The first series of tests was conducted on a rock-fill closure dam constructed of material hand-placed in the dry. The fill was constructed in accordance with the dimensions shown in fig. 2. The upstream slope was 1 on 1.5; the downstream slope was 1 on 3 from the crest to el 7, and 1 on 2 from el 7 to el -20. Maximum crown elevation was 17 and the average crown elevation about 16. Special effort was made to distribute the smaller particles of stone evenly throughout the fill.

Stability tests

11. Stability tests were conducted with various discharges and tailwater elevations for combined flow through and over the structure and with flow confined to overtopping only. With flow through and over the structure, the closure dam appeared very stable. Only one stone was displaced on the downstream side at a discharge of 66,000 cfs and an abnormally low tailwater elevation of 16.5. No displacement or movement of rock was noted with flow through the dam confined to the portion above el 10 or with all flow through the dam cut off by impervious covers placed on the upstream face. Although the rock-fill closure dam as designed appeared to be adequate for all discharge conditions, it was subjected to greatest attack at discharges below 40,000 cfs. With such discharges, the tailwater elevation was below the crown of the structure and the downstream face was subjected to the high-velocity nappe of the overtopping flow.

Seepage tests

12. The results of tests to record the amount of seepage through the rock-fill closure dam are shown in the following tabulation. Also shown is the reduced amount of seepage that occurred when an impervious blanket was placed on the upstream face of the closure dam to el 10.

Pool Elevation	Tailwater Elevation	Seepage Flow cfs	Seepage Flow above El 10, cfs
17	12.2	23,800	16,800
16	10.8	19,250	11,130
15	9.5	16,800	8,400
14	8.3	15,400	--
13.7	8	15,190	--
13	7.3	14,455	--
12	6.3	13,600	--
11	5.1	12,500	--
10	4.2	11,600	--

Since all rock particles were placed with the highest point at or below el 17, a large amount of flow passed between the crest rocks at a pool elevation of 17. A smaller amount passed through at pool el 16, and at el 15 all flow passed through the fill. The differences between the discharges listed in the last two columns of the preceding tabulation represent the amount of seepage that was eliminated by the impervious blanket on the upstream face of the dam to el 10.

Use of riprap blanket

13. One test was conducted to determine the effectiveness of a seal blanket of graded material dumped through flowing water onto the upstream slope. With an initial discharge of 23,800 cfs, pool el 17, and tailwater el 12.2, a blanket of crushed limestone (representing a prototype riprap size of about 12 in.) was placed on the upstream face of the closure dam to fill the voids in the surface rock. The addition of the blanket caused the pool to rise to el 17.7. A reduction in discharge to 12,600 cfs and tailwater to el 8 resulted in a drop in pool level to el 14.2. A blanket of crusher tailings (representing a prototype equivalent of crushed shells or gravel) placed on top of the riprap caused the pool to rise to el 17. A further reduction in discharge to 2650 cfs and tailwater elevation to 7.8 resulted in a pool elevation of 15. Most of this discharge passed through several holes in the seal blanket that were caused by imperfect placement of the blanket material.

Rock Fill Constructed in Flowing Water

Construction of closure section

14. To investigate the possible effect of the method of placement of the rock-fill material on stability and seepage characteristics, the model fill was rebuilt under simulated prototype construction conditions. Although the exact method of placement to be used in the prototype has not been decided upon, it is believed that the method used in the model is reasonably representative of prototype conditions. The rock fill constructed by dumping was similar to the hand-placed fill except that the average crest elevation was 17 instead of 16. Since the previous tests had demonstrated the need for a substantial thickness of seal blanket on the upstream slope, it was decided that the horizontal thickness of the main fill could be reduced 5 ft. This resulted in the slightly revised section shown in fig. 4.

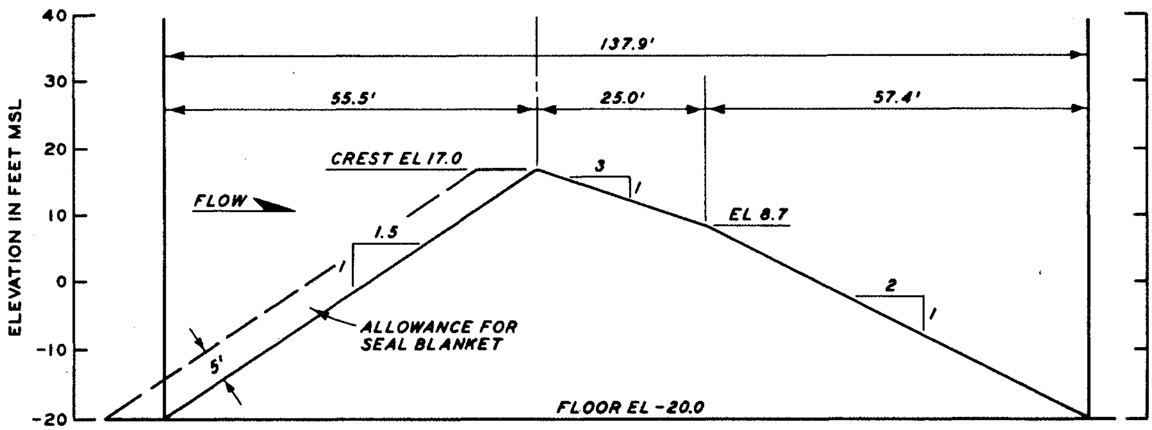

Fig. 4. Revised design rock fill constructed by dumping the stones into flowing water

15. A sliding-bottom dump box with prototype dimensions of 20- by 20- by 3.75 ft was used to dump the rock into the flowing water. This box was mounted on rollers on a movable transverse carriage, allowing it to be positioned at any given point over the fill area (fig. 5). Sta 1+00 (prototype) was arbitrarily located at the center line of the crest of the rock fill, and all dumpings were located with reference to stations and to the center line of the model flume. This allowed accurate placement of a complete layer of rock on the fill. Dumping was begun on the downstream

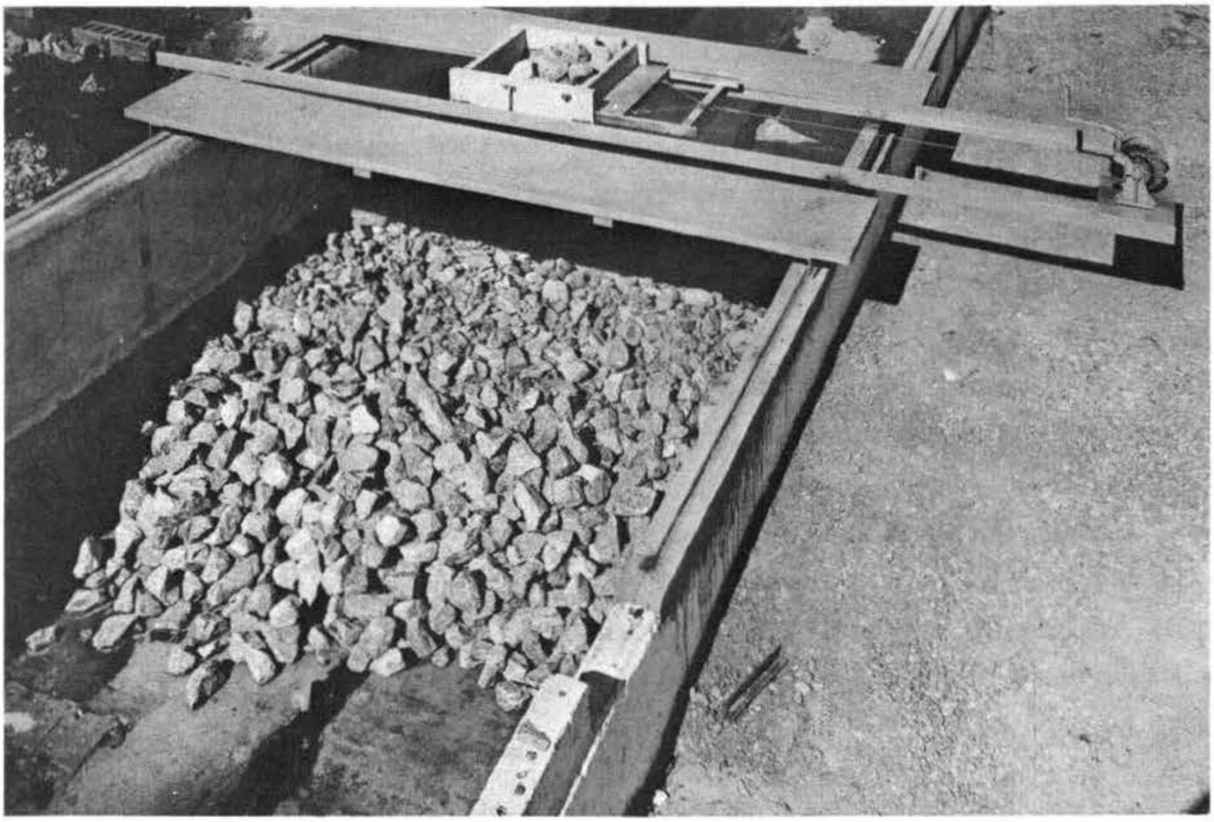

Fig. 5. Partially completed fill and apparatus used for dumping the rock

end of the fill, and progressed from the left side of the model flume to the right, continuing in this manner to the upstream end of the fill until the completion of one layer of rock; then the dump box was returned to the downstream end to begin placing the next layer. To insure a good protective covering of large cap rock, the first transverse dumping at the downstream end and the last dumping on the upstream end of each layer were of large rock only. In all other dumpings the rock was mixed to the previously established specifications.

16. The fill was constructed in four lifts, with a decreasing discharge used during construction of each successive lift, as specified by the Mississippi River Commission. Flow conditions during placement of each lift were as shown in the tabulation on the following page:

Construction Lift No.	Discharge cfs	River Stage Upstream	River Stage Downstream	Elevation of Top of Lift
1	121,700	30	29+	-13
2	111,500	30	29+	-3
3	101,000	30	29+	7
4	91,000	30	29+	17

The velocities over the fill for these flow conditions were those that may be expected in the prototype with a Mississippi River stage of 40 ft. The total actual volume of the dumped fill for the 100-ft length of closure section reproduced in the model was 10,618 cu yd (prototype), which is approximately 7 per cent more than the computed volume.

Stability tests

17. Stability tests with the discharges and water stages shown in table 1 indicated a stable section in that no rock movement was detected. Two or three rocks were seen to move during a discharge of 40,000 cfs, with pool and tailwater elevations of 20.5 and 15.5, respectively. However, for the same discharge and normal pool and tailwater elevations, no movement of the rock occurred. Velocities measured on the center line of the flume in the area downstream from the rock-fill closure dam during the stability tests are shown in table 2. The maximum velocity recorded was about 10 fps near the surface of the tailwater. Bottom velocities were negligible and upstream in direction. Flow conditions over the rock fill are shown in fig. 6.

Seepage tests

18. The results of seepage tests on the rock fill constructed in flowing water are given in the following tabulation.

Pool Elevation	Tailwater Elevation	Seepage Flow, cfs (No Blanket)	Seepage Flow, cfs (Riprap Blanket)
18	13.3	26,600	
17	12.1	22,800	16,800
16	11	21,700	15,400
15	9.8	19,600	14,000
14	8.9	18,200	12,565
13	7.6	16,800	12,075
12	6.6	15,400	11,585
10	4.7	14,000	

Also shown for comparative purposes is the reduction in seepage effected by

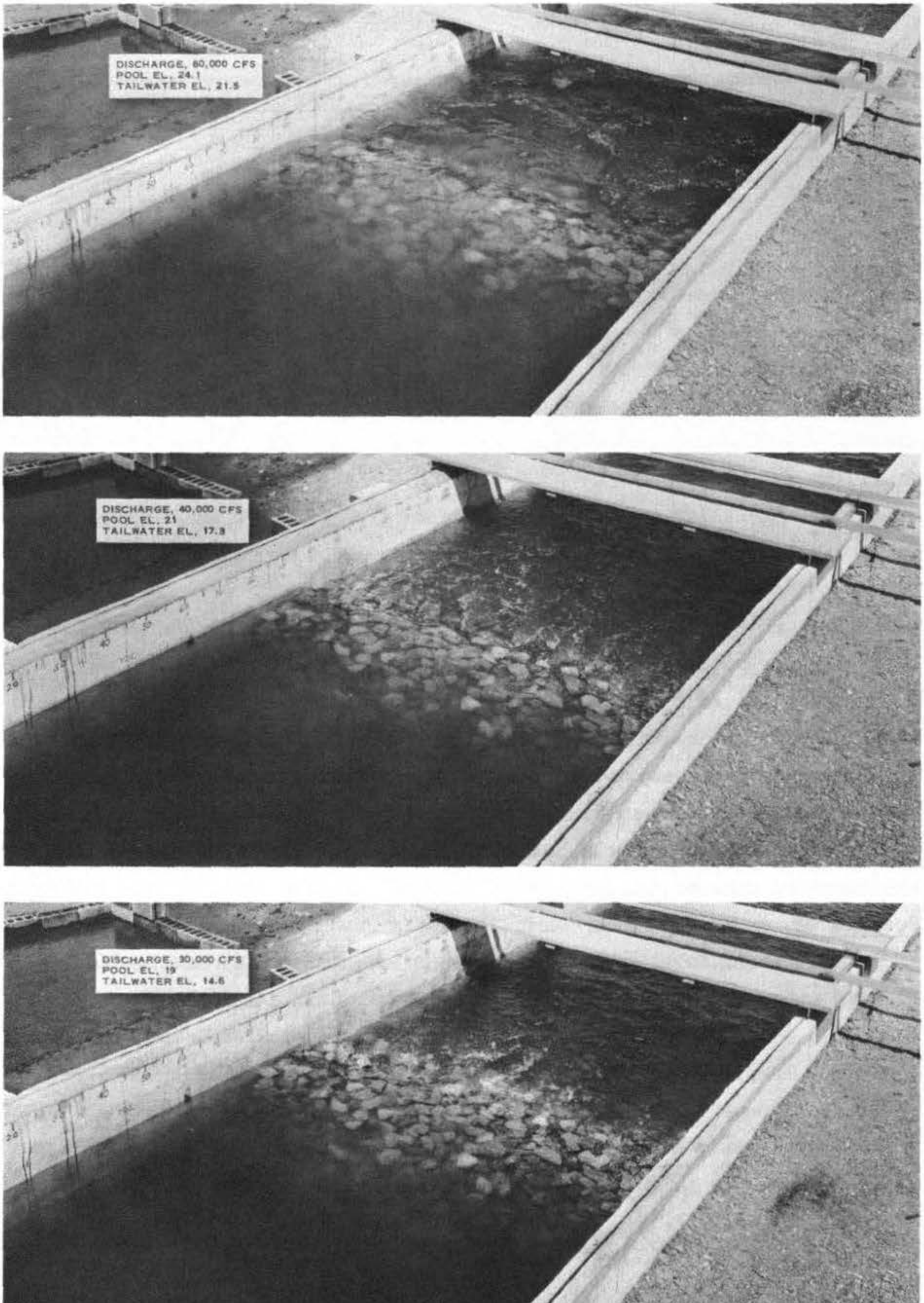

Fig. 6. Flow conditions over the rock fill

the placement of a 4-ft-thick blanket of 12-in. riprap over the entire upstream slope (fig. 7). The seepage flows listed on page 11 are somewhat greater than those through the fill placed in the dry (see paragraph 12).

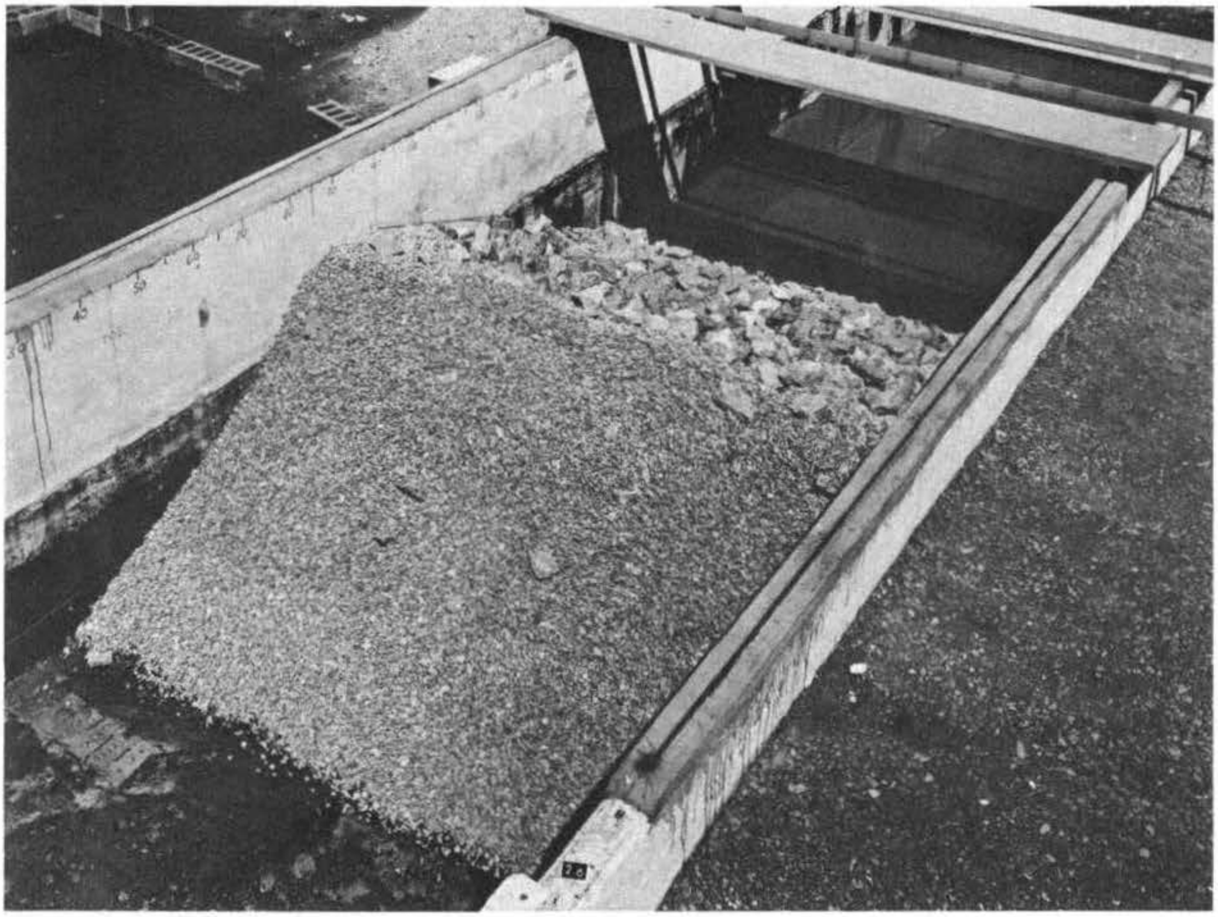

Fig. 7. Riprap on upstream slope of rock fill

Use of riprap blanket

19. The 4-ft-thick blanket of crushed rock, mentioned in the previous paragraph, was placed on the upstream slope by dumping stones into flowing water. The stones represented a prototype riprap size of about 12 in. Placement of the blanket was begun at the upstream toe of the fill and progressed transversely from left to right. Succeeding passes placed the blanket at higher elevations on the fill. The total volume of stones dumped was 1000 cu yd (prototype).

20. At the start of riprap placement, the discharge through and over the closure dam was 23,800 cfs, with a pool elevation of 20 and a

tailwater elevation of 18.8. After the first complete traverse of the fill no change in flow conditions was noted. The pool and tailwater elevations were readjusted to 18.5 and 15.5, respectively, and the second traverse was made. Completion of the second traverse caused the pool to rise to el 18.7. Pool and tailwater elevations were readjusted to 17 and 10.5, respectively, and the third traverse was made, completion of which brought the blanket to el 10 (sta 0+90) and the pool elevation to 18.2. The discharge was reduced to 18,200 cfs, with a pool elevation of 16.9 and a tailwater elevation of 11.5. Placement of the blanket was then completed to the crest of the closure dam, which caused the pool to rise to el 17.3. Total volume of riprap placed was 850 cu yd (prototype). An additional 150 cu yd of material was placed at obvious weak points in the blanket, after which the pool rose to el 17.8.

21. Actual values of seepage with the 4-ft blanket in place are shown in paragraph 18. Velocities measured at the downstream toe of the fill were negligible.

Effect of seal cover

22. To effect a further reduction in seepage flow, a seal cover of crusher tailings representing crushed shell and gravel was dumped through flowing water onto the previously placed riprap blanket. At the start of dumping the discharge was 13,900 cfs, with a pool elevation of 15 and a tailwater elevation of 9.1. Two thin layers of the fine material were placed between the upstream toe and sta 0+90. As this material was placed on the upstream slope, the discharge and tailwater elevations were adjusted downward to prevent the pool from overtopping the closure dam. Flow conditions with the seal cover installed to sta 0+90 were: discharge 1850 cfs, pool el 17, and tailwater el 9.3. Completion of the seal cover to sta 1+00 caused the pool to rise to el 17.5. Seepage through the closure dam with a pool elevation of 15 and a tailwater elevation of 7.3 was 1050 cfs. The total volume of fines dumped on the slope was 370 cu yd (prototype), which should result in approximately a 1.5-ft-thick cover of fines over the riprap. However, since a large percentage of this material went to fill the voids between the pieces of riprap, the actual thickness of the riprap was less than 1 ft. Table 3 shows a sieve analysis of both the fines and the riprap material, and fig. 8 shows the completed seal cover.

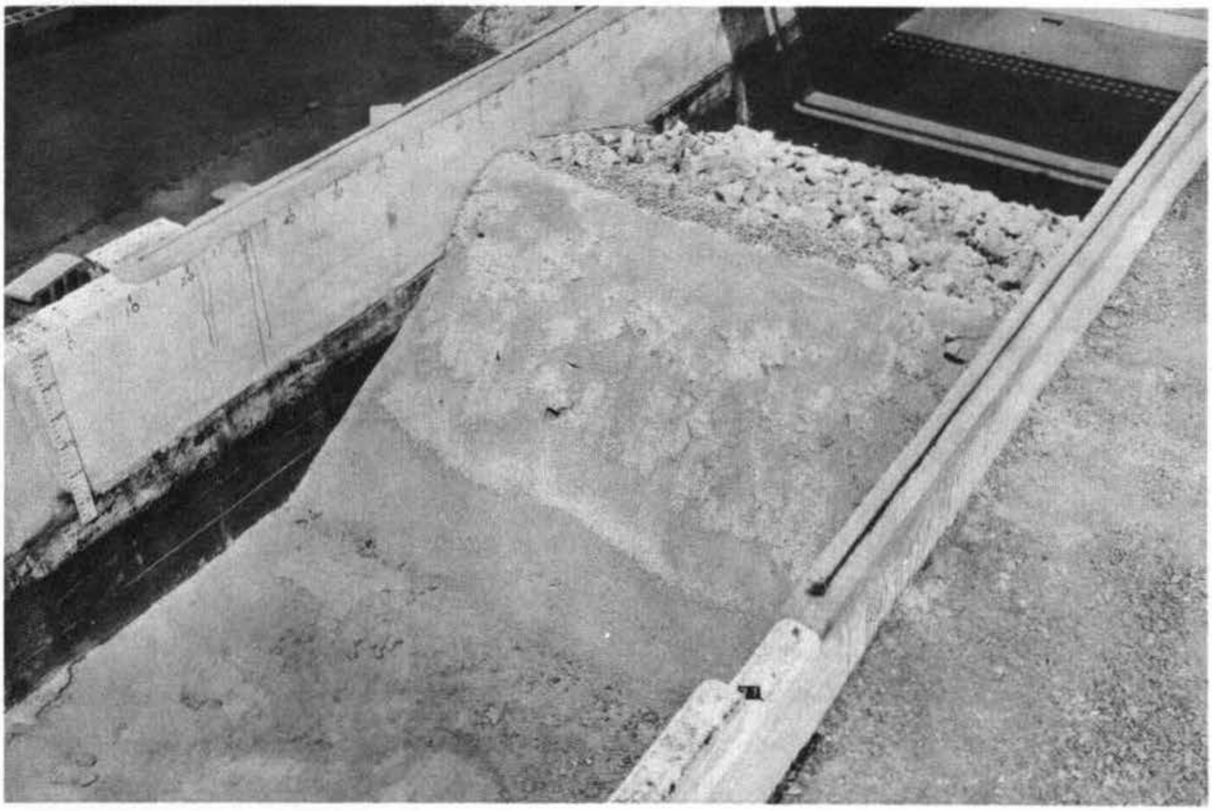

Fig. 8. Completed seal cover placed on top of the riprap blanket on upstream slope of fill

23. Tests to study the stability of the seal cover were conducted for the following conditions of flow:

Discharge, cfs	Pool Elevation	Tailwater Elevation
1,850	17.5	9.5
3,500	19	11.5
16,800	21	14.7
40,000	24.1	19.7
87,000	29	27

For discharges of 1850 and 3500 cfs, practically no movement of the seal cover was observed except in the immediate vicinity of the crest. For a discharge of 16,800 cfs, most of the seal cover was removed between sta 0+90 and 1+00. However, those fines that had lodged between the individual pieces of the 4-ft riprap blanket remained in place. An increase in the discharge to 40,000 cfs caused most of the fines to be removed between sta 0+80 and 0+90 as well as the loss of a few pieces of riprap from the 4-ft blanket near the crest. Also, two or three pieces of cap rock were moved

to new locations just downstream from the crest by the overtopping flow (fig. 9). An increase in the discharge to 87,000 cfs caused little additional movement of the riprap blanket although most of the seal material was removed to sta 0+75 (fig. 10). Seepage loss for a pool elevation of 15 and tailwater elevation of 7.3 was increased to 1750 cfs by removal of the seal cover by the overtopping flow.

Determination of Maximum Slopes

Rock placement under predicted flow conditions

24. In an effort to determine the maximum slopes that would be stable, a short series of tests was conducted in which the rock fill was constructed by dumping stones into flowing water. The slopes of the upstream and downstream faces of the fill were allowed to assume their natural angle of repose. The fill was constructed by successive dumping of rock along the crest of the fill. The fill was constructed in four lifts, with four discharge conditions (see tabulation in paragraph 16).

25. The resulting completed fill had a crest elevation of 17 and upstream and downstream slopes of about 1 on 1. Stability tests, with flows established according to predicted Mississippi River stages (table 1), indicated no significant movement of rock particles at high flows. At a discharge in the range of 30,000 to 40,000 cfs, however, a general sloughing of the rock at and immediately downstream from the crest occurred, creating a somewhat flatter slope in the vicinity of the crest.

Rock placement under critical flow conditions

26. Since tests had indicated the desirability of a flatter slope downstream from the crest of the rock fill, additional rocks were added under flow to raise the crest back to el 17 and flatten the upper portion of the downstream slope. These additional rocks were placed under the most critical condition of flow with regard to rock movement: discharge, 30,000 cfs; pool el, 17; tailwater el, 13. Rock was dumped along the crest and 5 ft downstream until a uniform stable fill was obtained.

27. The profile of the resulting closure dam consisted of a

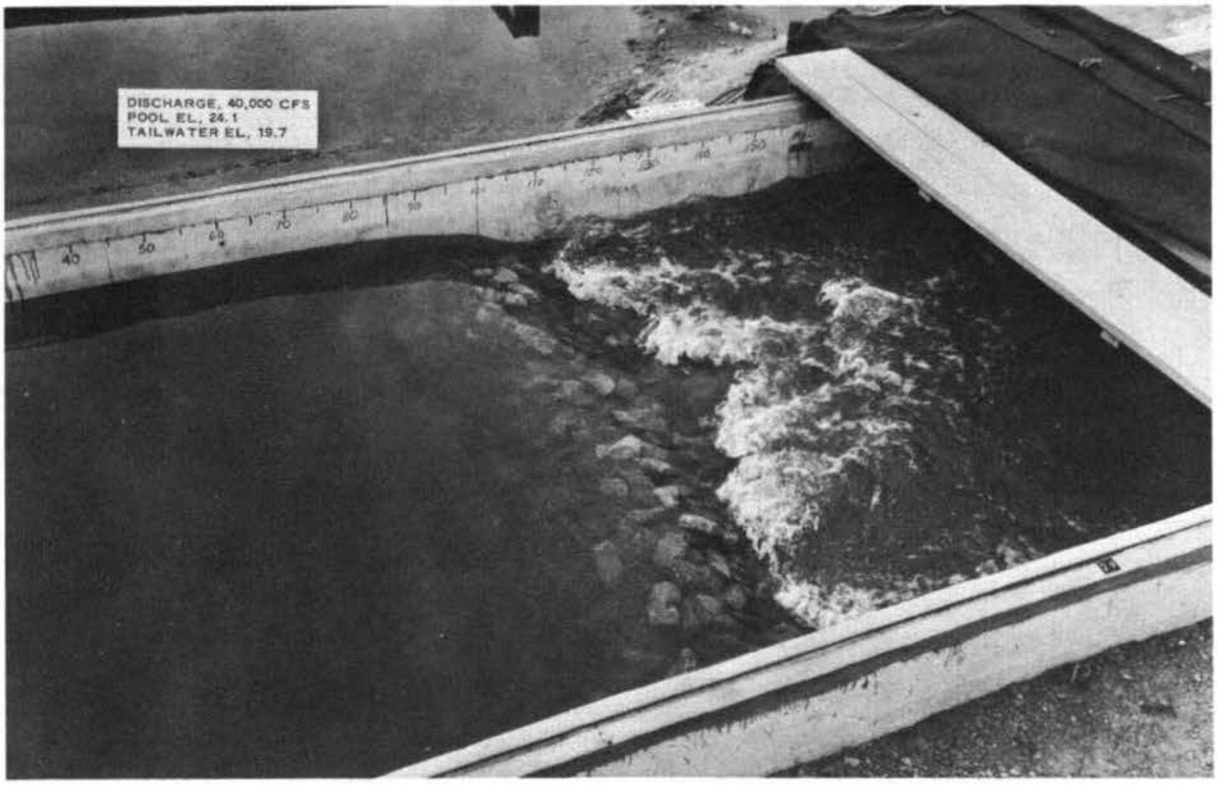

Fig. 9. Overtopping flow during tests of the stability of the seal cover

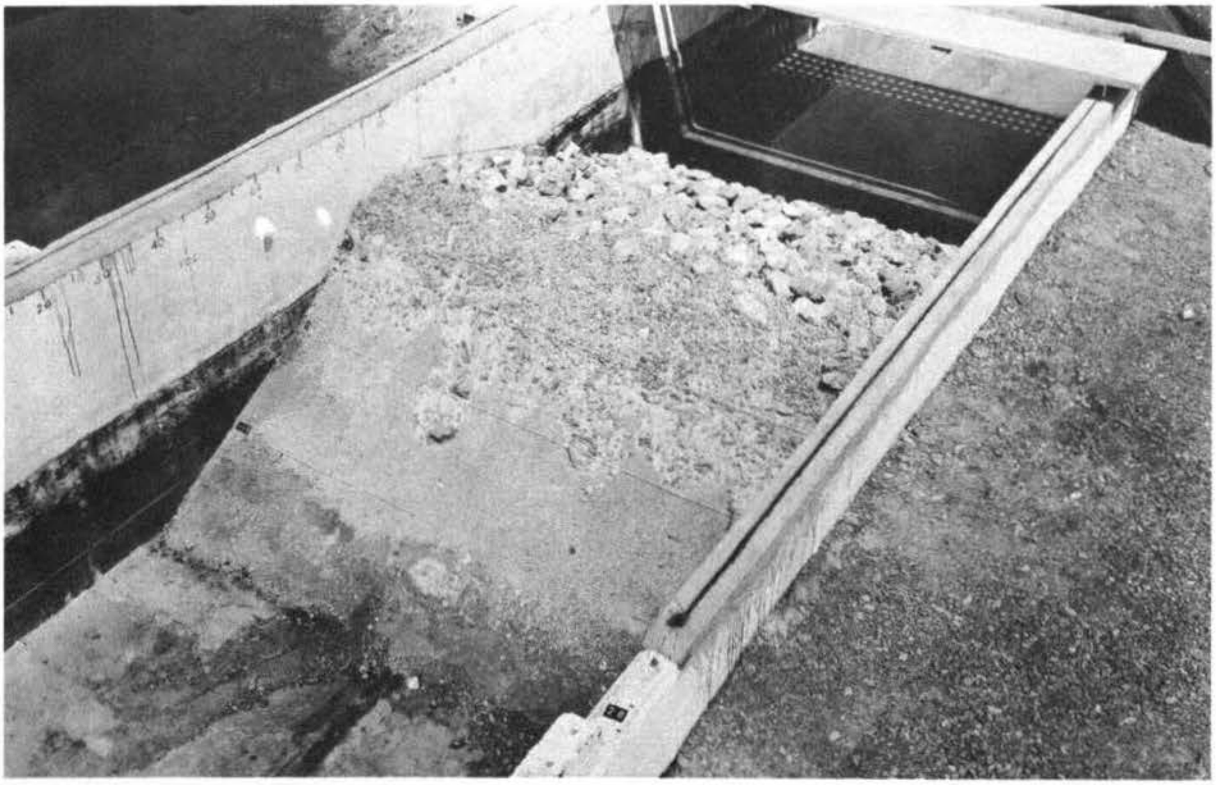

Fig. 10. Crest of rock fill after stability tests of the seal cover.
Note loss of seal cover near the crest

continuous upstream slope of 1 on 1 to el 17 (crest of fill), a 1-on-2 downstream slope from the crest to el 7, and a 1-on-1 slope from el 7 to the channel floor at el -20. Stability tests with and without an impervious blanket on the upstream face indicated that the rock-fill closure dam would be adequate for all anticipated flow conditions. A rock fill of this cross section would contain about 40 per cent less rock than the cross section initially investigated.

PART IV: DISCUSSION OF RESULTS

28. Tests of the originally proposed rock-fill section showed conclusively that no displacement of individual stones will occur under any conceivable flow conditions. The model tests were concerned with stability of the slopes only, and consequently no predictions can be made regarding other forms of stability, such as that against sliding of the entire fill, or failure of the asphalt mat and thin riprap blanket under the fill. Measurements of bottom velocities indicated no tendency toward scour at the downstream toe of the fill.

29. It was demonstrated that the seal cover on the upstream face is necessary if seepage flow is to be reduced below about 20,000 cfs. No difficulty was experienced in placing an effective blanket in the model although a few projecting rocks are possible sources of weakness in the blanket and create zones of greatest seepage flow. Use of the riprap blanket and a seal cover of finer material should make velocities negligible in the vicinity of the final sand-fill closure dam. The rock-fill closure dam with the originally proposed cross section should be completely safe in all respects if the upstream blanket of riprap and finer rock is used.

30. The tests indicated that consideration can be given to the use of a thinner cross section for the rock fill. A 40 per cent saving in the volume of rock, as well as other economies in construction, could be effected by use of the revised design cross section tested in this study.

Table 1

Stage-Discharge Relations at Closure Dam

Discharge, cfs	Pool Elevation	Tailwater Elevation
	Section Constructed in Dry	
93,000	28.75	27
66,000	23.25	21.25
60,000	22.5	20.5
43,000	22	18.5
40,000	20	16.5
30,000	18	13
30,000	20.5	15.5
24,400	19	14
	Section Constructed in Flowing Water	
93,000	29	27.2
60,000	24.1	21.5
40,000	21	17.3
30,000	19	14.6

Table 2

Velocities below Closure Dam

Station	Elevation	Current Direction	Prototype Velocity, fps
	Discharge, 93,000 cfs; Pool El, 29; Tailwater El, 27.2		
1+82 (Downstream toe of fill)	-19	Upstream	1.5
	-10	Upstream	4.0
	0	Upstream	2.2
	10	Downstream	4.0
	20	Downstream	10.4
2+42	-19	Upstream	2.2
	-10	Upstream	2.2
	0	Downstream	2.2
	10	Downstream	2.2
	20	Downstream	7.7
3+32	-19	------	0
	-10	------	0
	0	------	0
	10	------	0
	20	Downstream	4.0
	Discharge, 60,000 cfs; Pool El, 24.1; Tailwater El, 21.5		
1+82	-19	Upstream	1.5
	-10	Upstream	2.2
	0	Upstream	1.5
	10	Downstream	1.5
	20	Downstream	10.1
2+42	-19	Upstream	2.2
	-10	Upstream	2.2
	0	------	0
	10	Downstream	4.5
	20	Downstream	9.0
3+32	-19	------	0
	-10	------	0
	0	Downstream	1.5
	10	Downstream	1.5
	20	Downstream	1.5
	Discharge, 40,000 cfs; Pool El, 21; Tailwater El, 17.3		
1+82	-19	------	0
	-10	------	0
	0	Downstream	4.0
	10	Downstream	5.8
2+42	-19	------	0
	-10	------	0
	0	------	0
	10	Downstream	4.0
3+32	-19	------	0
	-10	------	0
	0	------	0
	10	Downstream	2.2
	Discharge, 30,000 cfs; Pool El, 19; Tailwater El, 14.6		
1+82	-19	------	0
	-10	------	0
	0	------	0
	10	Downstream	4.0
2+42	-19	------	0
	-10	------	0
	0	------	0
	10	Downstream	2.2
3+32	-19	------	0
	-10	------	0
	0	Downstream	1.5
	10	Downstream	2.2

Table 3

Gradation of Upstream Seal Cover Material

Sieve Size (Model)	Equivalent Prototype Size, in.	Per Cent Passing by Weight
	Riprap Layer	
1 -in.	10	100
3/4-in.	7-1/2	85
1/2-in.	5	29
3/8-in.	3-3/4	7
No. 4	2-1/2	2
No. 10	1	2
No. 20	1/2	1
No. 40	1/4	1
No. 80	1/8	1
No. 200	1/20	1
	Fine Layer	
No. 4	2-1/2	100
No. 10	1	84
No. 20	1/2	48
No. 40	1/4	28
No. 80	1/8	15
No. 200	1/20	7